DOCUMENT RESUME

ED 266 846 PS 015 609

TITLE	Nutritional Management of Acute Diarrhea in Infants and Children.
INSTITUTION	National Academy of Sciences-National Research Council, Washington, D.C. Food and Nutrition Board.
SPONS AGENCY	Agency for International Development (IDCA), Washington, DC.
PUB DATE	85
CONTRACT	AID-ta-C-1428
GRANT	DAN-0262-G-SS-4086-00
NOTE	51p.
AVAILABLE FROM	Food and Nutrition Board, National Research Council, 2101 Constitution Avenue, N.W., Washington, DC 20418 (Single copy free).
PUB TYPE	Guides - Non-Classroom Use (055)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Children; *Disease Control; *Diseases; Guidelines; *Infants; *Nutrition; Research Needs
IDENTIFIERS	*Diarrhea; Food Selection; *Nutritional Therapy; Oral Rehydration Therapy

ABSTRACT

Written primarily for health professionals advising on programs and policy related to nutrition and diarrhea therapy, this report is aimed at management of diarrhea in less-developed countries, but its information and technical insights are relevant to an understanding of diarrhea and its management throughout the world. Technical in orientation and not a manual itself, the report can be used as a guide in preparing manuals, training courses, public education materials, and communication strategies directed toward all those responsible for child care. The first chapter examines the nutritional consequences of acute diarrhea and the premise that continued feeding during diarrhea is not generally harmful and can be highly beneficial. Chapter 2 presents general guidance for nutritional management, including comments on choice of foods, food preparation, frequency of feeding, and monitoring of therapy. The chapter also provides an overview of oral rehydration therapy, which is aimed at correcting electrolyte losses and maintaining fluid balance. Chapter 3 outlines research needs emerging from a review of the related literature, and Chapter 4 summarizes major findings. Appended are tables indicating estimated energy needs for recovery from the effects of diarrhea and general conclusions suggested by those estimates. Seven pages of references conclude the document. (RH)

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Nutritional Management of Acute Diarrhea in Infants and Children

Subcommittee on Nutrition and
Diarrheal Diseases Control
Committee on International Nutrition Programs
Food and Nutrition Board
Commission on Life Sciences
National Research Council

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Subcommittee on Nutrition and
Diarrheal Diseases Control
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National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C. 1985

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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The study summarized in this report was supported by Contract AID-ta-C-1428 and Grant DAN-0262-G-SS-4086-00 from the Agency for International Development.

Copies available from:

Food and Nutrition Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Printed in the United States of America

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PREFACE

In October 1983, the Office of Nutrition of the Agency for International Development (AID) asked the National Research Council to review nutritional aspects of acute diarrhea in children and to prepare guidelines for incorporating nutritional considerations into its treatment. In response, the Subcommittee on Nutrition and Diarrheal Diseases Control was established in September 1984 under the auspices of the Committee on International Nutrition Programs of the Food and Nutrition Board in the Research Council's Commission on Life Sciences. This report presents the results of the subcommittee's efforts.

The report is written primarily for health professionals who will be advising on programs and policy related to nutrition and diarrhea therapy. It is technical in orientation and, although not a manual itself, can be used as a guide in preparing manuals, training courses, public education materials, and communication strategies directed toward all those responsible for child care. The message is aimed at management of diarrhea in less-developed countries, but the information and technical insights are relevant to an understanding of diarrhea and its management throughout the world. Similarly, although many children in industrialized countries are better protected from the nutritional consequences of acute diarrhea, the recommendations in this report hold equally well for children of all countries.

The first chapter examines the nutritional consequences of acute diarrhea and the premise that continued feeding during diarrhea is not generally harmful and

indeed can be highly beneficial. Chapter 2 presents general guidance for nutritional management, including comments on choice of foods, food preparation, frequency of feeding, and monitoring of therapy. The chapter also provides an overview of oral rehydration therapy, which is aimed at correcting electrolyte losses and maintaining fluid balance. Chapter 3 outlines research needs emerging from the subcommittee's literature review, and Chapter 4 summarizes the subcommittee's major findings.

Two aspects of the diarrhea-nutrition complex are not covered in this report: the nutritional management of severe protein-energy malnutrition, including the diarrhea accompanying it, and the relationship of nutritional state of the child to susceptibility to diarrheal and other infections. Both have been extensively reviewed elsewhere (see, for example Torun and Viteri [48] and Mata et al.[28]).

The subcommittee wishes to thank members of the Committee on International Nutrition Programs and the Food and Nutrition Board for their helpful comments on drafts of the report. The subcommittee also acknowledges the continued interest and support of Martin J. Forman and Nicolaas Luykx of the Office of Nutrition, AID. In addition, the subcommittee is grateful for the contributions of Sushma Palmer, Executive Director, Food and Nutrition Board, who reviewed and commented on drafts; Shirley E. Cole of the Food and Nutrition Board staff, who provided administrative and secretarial assistance early in the project; Avis I. Harris, also of the Food and Nutrition Board staff, who was responsible for manuscript preparation and for design and layout of the final report; and Norman Grossblatt, of the Commission on Life Sciences staff, who edited the report.

Most importantly, the subcommittee wishes to express its appreciation to Linda D. Meyers, Senior Staff Officer, Food and Nutrition Board, and convener of the subcommittee, who worked closely with us throughout the project. Her contributions were invaluable, and working with her was a pleasure for all of us.

Richard A. Cash

Richard A. Cash
Chairman, Subcommittee on Nutrition
and Diarrheal Diseases Control

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1

NUTRITIONAL CONSEQUENCES OF ACUTE DIARRHEA

INTRODUCTION

Nearly all children suffer from diarrhea. Preschool children in some developing countries have diarrhea 10-20% of the time, or about 35-70 days a year.[5] Depending on etiology, as many as 10% of children with diarrhea become severely dehydrated, and 0.5% of all those with diarrhea may die of it.[46] Oral rehydration therapy (ORT) saves lives by replacing lost body fluids and electrolytes. If universally used, ORT could significantly reduce diarrhea-related mortality and morbidity.

Besides causing a loss of water and electrolytes, acute diarrhea has important adverse effects on the nutritional status of a child. Among the common infectious diseases, diarrheal diseases are the most common contributors to malnutrition.

In industrialized countries, nutritional reserves of children are generally sufficient to offset the detrimental effects of diarrhea. The greater availability of high-quality foods and the lower incidence of diarrhea in individual children also reduce its adverse nutritional consequences by permitting rapid catch-up growth during convalescence. In some developing countries, however, 30% or more of the children may be moderately to severely malnourished. In a malnourished child, even a brief episode of diarrhea can seriously affect nutritional status and require prompt attention to prevent further nutritional deterioration and its consequences. Furthermore, the high frequency of diarrhea allows less time for recovery and catch-up growth between episodes.

Diarrhea contributes to malnutrition through reduction in food intake, decrease in absorption of nutrients, and increase in catabolism of nutrient reserves. Physiologic causes of a decrease in food intake include anorexia, nausea, and vomiting, all of which may be associated with electrolyte loss, imbalance, and dehydration, although the exact mechanisms are not well defined. Maldigestion and malabsorption can occur in children in whom intestinal digestive enzyme activity is decreased and transit through the intestine is more rapid. Malabsorption is excerbated by the preferential destruction of mature cells often caused by the infection. Some invasive bacteria (e.g., shigellae), viruses (e.g., measles), and protozoa (e.g., amebae) can directly damage the intestinal lining and lead to protein loss. Bacterial overgrowth in the upper portions of the intestine can accentuate malabsorption, and competition with intestinal helminths and bacteria for available nutrients can reduce the availability of food to the child. Fever, generally associated with invasive intestinal organisms, results in increased metabolic rates, which lead to increased energy requirements and losses of muscle and visceral protein. In addition, food is often withheld during the acute illness.

These nutritional consequences of diarrhea, described in some detail in this chapter, often set the stage for more severe illness, which can lead to increasingly severe nutrient deficiencies. The potential for the accelerated deterioration of nutritional status demands that lost fluids and nutrients be rapidly replaced.

DECREASE IN DIETARY INTAKE

Hospital-based investigations of dietary intake by children with diarrhea have consistently shown a reduction in food intake, and hence caloric intake, during their illness. The findings vary considerably with the site of the study, the comparison group used, and the children's major sources of dietary energy. Three clinical studies from Bangladesh noted a 30-50% decrease in caloric intake during the early days of illness, compared with an illness-free control group or with the same patients after recovery from diarrhea.[18,31,45] The comparison groups were offered a relatively energy-dense hospital diet frequently throughout the day and

thus consumed substantially more energy than illness-free children from the same country who consumed their usual diet. The apparent decrease in energy consumption during illness would presumably be smaller if estimated on the basis of the usual dietary intake at home. No significant decrease in breast-milk consumption was detected during illness in the two studies in which it was measured.[18,45]

Three community-based studies of dietary intake during illness have produced conflicting results. Two reports from Central America identified a reduction in energy consumption by young children who were completely weaned from the breast.[27,28] In these field studies, the decrease in energy consumption averaged only 15-20%, possibly because the energy consumed was compared with the children's usual intake, not with a hospital diet. In contrast, a recent study of Bangladeshi infants, who were still receiving most of their dietary energy from breast milk, did not find significant decreases in energy intake during diarrhea.[6]

Many explanations for the observed reductions in energy intake are possible, including food withholding (as dictated by parental beliefs or recommendations by health-care personnel), substitution of nutrient-poor rehydration solutions for other dietary components, reduction in the nutrient density of the diet, vomiting, and anorexia. No studies have attempted to distinguish among these factors, and data are insufficient to determine how diarrhea affects dietary intake or to assess the impact on appetite of specific metabolic disturbances, such as acidosis and electrolyte imbalances.

Despite all efforts to encourage continued feeding during diarrhea, net nutrient losses occur, in part because of anorexia (unavoidable in some cases), malabsorption, and increased catabolism.[21,30,31] In growing children, these losses are manifested by a slowing of growth or by persistent weight loss even after full rehydration. Consumption greater than normal is required during convalescence to compensate for nutrient losses and to permit catch-up growth. Indeed, young undernourished children fed energy-rich and protein-rich foods increase their intake substantially and might gain weight at up to 7 times the expected rate until they catch up to their optimal nutritional

status.[50,51] However, the traditional weaning diets in many societies are composed primarily of staple foods that are diluted to a semisolid consistency. The bulkiness of this diet limits the amount of food that can be consumed and therefore limits the rate of catch-up growth. High-quality, well-balanced, energy-dense foods must be added to such diets during illness and recovery if the catch-up growth rate is to be optimal and preillness nutritional status is to be restored.

DECREASE IN INTESTINAL ABSORPTION

Digestion and absorption are complicated and involve several organ systems acting in concert. Protein requires digestion by proteolytic enzymes, primarily pancreatic, before it is absorbed as small peptides and amino acids. Triglycerides, the major form of dietary lipid, must be digested by lipases to their component fatty acids and monoglycerides and then be incorporated with bile acids into water-miscible, mixed micelles for efficient absorption. Starches are broken down to oligosaccharides (primarily maltose and dextrins) by salivary and pancreatic amylase and in part by brush-border enzymes. These oligosaccharides and dietary sugars are ultimately hydrolyzed by brush-border disaccharidases before active or facilitated transport of the component monosaccharides across the cellular membrane can occur. Some vitamins and minerals have specific intestinal transport pathways.

The intestinal villus cells, which are partly responsible for digestion and absorption of dietary components, migrate upward from the crypts of the mucosa to the villus tips and are eventually sloughed into the intestinal lumen. The entire intestinal surface is renewed about every 3 days. Mucosal renewal probably requires stimulation by the diet and pancreatic secretions. During chronic starvation and after acute withdrawal of food, mucosal cell turnover and production of brush-border hydrolytic enzymes decrease. Withholding of food to control diarrhea might thus contribute to mucosal abnormalities and worsen malabsorption and diarrhea when feeding is reintroduced.

The efficiency of intestinal absorption is determined not only by the physiologic maturity and state of health of the child, but also by the dietary sources of particular nutrients. In general, breast milk and other foods derived from animal sources are more readily digested than those obtained from plant sources. The digestibility and bioavailability of nutrients from vegetable products, however, vary widely according to the specific food, the way it is processed, and the extent of cooking. Interactions among specific foods or nonnutritive components (such as phytates, tannins, and fiber) can also influence digestion and absorption of individual nutrients. These factors should be considered in planning the dietary management of persons with diarrhea.

Intestinal absorption is commonly impaired during and after acute intestinal infections in humans.[8,41] Because the gastrointestinal system is not fully mature at birth, infants and young children might be particularly susceptible to the adverse effects of intestinal infections on digestive and absorptive capacity. Clinical studies of children with acute intestinal infections have documented malabsorption of macronutrients -- carbohydrates, fat, and protein.

- Transient malabsorption of carbohydrates has been observed often, especially in episodes of viral origin.[24,42] This malabsorption is presumably caused by secondary disaccharidase deficiencies, impairment in monosaccharide transport, alterations in intestinal motility, and loss of intestinal surface area. It remains unknown whether intestinal infections alter pancreatic function, either directly or by reducing the endocrine stimulation of pancreatic secretion by damaged intestinal mucosa.

- Malabsorption of fat is common during and after diarrhea.[25] An increase in fecal excretion of bile acids, possibly secondary to impairment of ileal transport or to bacterial overgrowth in the small intestine, can result in intestinal bile acid concentrations that are too low for micelle formation, which is necessary for fat absorption.[19]

• The efficiency of protein absorption during diarrhea has not been studied extensively, but marked loss of endogenous protein in stool can occur, especially with dysentery.[40]

Despite the demonstration of increased fecal nutrient losses during intestinal infections, substantial nutrient absorption occurs. Studies with either common mixed diets or synthetic formulas have found that an average of 80-90% of ingested carbohydrate, 50-70% of fat, and 50-75% of nitrogen are absorbed, depending on the food sources of these nutrients, the amounts ingested, and the type and severity of diarrhea.[7,30] Thus, although absorption of macronutrients can be 10-30% lower than that in illness-free children consuming the same diets, nutrient absorption during diarrhea is sizable. This points to a nutritional advantage of continued feeding. In the few comparative studies that have been completed, increasingly high dietary intakes were associated with absorption of increasingly high amounts of ingested nutrients.[7,12,26]

Nutrient-balance studies, which measure the amounts of specific nutrients ingested and excreted in feces, do not distinguish between the excretion of exogenous (dietary) and endogenous nutrients. Febrile illnesses and intestinal infections with agents that invade the mucosa and cause inflammation result in losses of endogenous nutrients. Fever increases the basal metabolic rate and energy requirements.[21] It also triggers increases in urinary concentrations of a variety of trace minerals and an increase in tissue catabolism, which leads to substantial losses of nitrogen stores from contractile muscle and the viscera. The cumulative balance of these nutrients can remain negative for many days or even weeks after the onset of illness. During dysentery, the additional loss of blood and blood proteins can be large. These illnesses often precipitate acute protein-energy malnutrition of the kwashiorkor type if dietary intake is not kept high enough to offset these stress-induced losses.

As noted earlier, in the absence of food intake, the turnover and maturation of intestinal cells lessen; that decreases the surface area available for the end stages of digestion and absorption. Pancreatic function also decreases in acute or chronic malnutrition. Even for these reasons alone, the continued feeding of nutrients in acute diarrhea is necessary.

INCREASE IN NUTRIENT REQUIREMENTS

Age-specific nutrient requirements and recommended intakes or allowances for normally growing children are published periodically by national and international authorities.[14,15,35] Recommended allowances are targeted to the needs of approximately 98% of the members of specified normal populations. Recommended allowances of most nutrients are calculated by estimating average requirements for the population and adding some quantity to account for individual variability. Recommended intakes of energy beyond early infancy are calculated by summing average estimates of the needs for maintenance, growth, and activity.

When the nutrient needs of an undernourished child with acute diarrhea are estimated, the nutrient losses imposed by the illness and by catch-up growth must be added to the baseline allowances for healthy children. There is no need for an additional allowance for physical activity, because that is included in the estimation of recommended allowances.

Nutrient needs in diarrhea are increased because intestinal absorption is impaired, metabolic rates are increased, and tissue must be repaired. The increased needs are difficult to estimate. Age- and disease-specific data on children are meager; impairment of intestinal absorption in diarrhea is highly variable and might depend in part on the etiology of the illness. In the absence of fever or sepsis, needs for metabolism are not likely to be much more than 10% above normal. Nutrient needs for tissue repair are probably included in the estimates for catch-up growth.

The metabolic cost of catch-up growth is easier to estimate than that of diarrhea. Once fluid losses have been corrected, the weight-for-height deficit can be determined. Although there is no consensus on the extra nutrient requirements for tissue accretion during catch-up growth, estimates of 5-8 kcal and approximately 0.4 g of protein per gram of desired gain of lean body mass appear reasonable. The daily caloric requirement for growth is approximately 2% of the recommended energy intake for a 2-year-old child.[49] If diet is not limiting, catch-up growth after diarrhea might be as much as 7 times as great as average daily

growth.[50,51] Thus, 14% (i.e., 7 x 2%) more energy intake might be needed to provide for maximal catch-up. The comparable figures for protein are 12% of the daily allowance for growth and 84% (7 x 12%) for catch-up growth. To allow for additional factors that could interfere with utilization of food, it has been suggested that diets during periods of catch-up growth provide an increment of 30% of energy and 100% of protein.[50]

The above considerations suggest that the provision of energy at least 25% above the estimated mean requirement for normal children is a conservative goal during early convalescence. Estimates of energy intake and weight gain required for recovery from various categories of weight loss according to selected recovery periods are presented in the Appendix. A target protein intake of twice the recommended allowance would be an appropriate goal to cover losses due to malabsorption, increases in needs that result from catabolic losses, and inefficient use when energy is inadequate because of lowered intake or malabsorption. It must be recognized that these figures are only gross estimates of the actual requirement of a given child during recovery from illness. These estimates of intake should not be used by themselves as the target of therapy. Rather, the growth response of a child should be used to monitor the adequacy of dietary intake.

POTENTIAL COMPLICATIONS OF CONTINUED FEEDING

Although continued feeding during diarrhea is advocated for its favorable nutritional consequences, the potential complications of intestinal malabsorption must be considered. Unabsorbed water-soluble substances exert an osmotic force that draws water and, to a lesser extent, electrolytes into the intestinal lumen. Colonic bacterial fermentation of unabsorbed carbohydrate that reaches the large intestine produces short-chain organic acids, increases the number of small molecules, and thus contributes to systemic acidosis and augments diarrhea.[47] Dietary intake that exceeds intestinal absorptive capacity can result in a greater risk of dehydration, electrolyte imbalance, and systemic acidosis.

Early studies of food intake during diarrhea found increased fecal losses in children who ate more. However, these studies used milk-based diets.[12] Human milk appears to be well tolerated.[8] Recent studies with lactose-free diets have found no increase in severity of diarrhea among children who consumed these diets, compared with children who received only oral glucose-electrolyte solutions.[7,44]

2

THERAPY FOR DIARRHEA

ORAL REHYDRATION THERAPY

Death associated with acute diarrhea is most often due to the dehydration that results from the loss of body water and electrolytes in the stool. Lost water and electrolytes can usually be replaced orally, and few cases require intravenous therapy to prevent serious complications or death. Because deficits of similar size can occur whether diarrhea is associated with bacteria or with viruses, treatment depends more on the size of the deficit than on the specific type of diarrhea or other characteristics of the patient. Thus, it is possible to use similar hydration solutions in persons with different types of diarrhea and of different ages.

Dehydrated children who are not in shock and who are able to drink should be rehydrated orally. The value of oral rehydration therapy (ORT) in industrialized and developing countries has received considerable attention and has been well documented.[10,11,36,37,43]

The oral rehydration solution formula recommended by the World Health Organization (WHO) contains, in millimols per liter, the following: sodium, 90; chloride, 80; potassium, 20; glucose, 111; and a base, such as citrate tribasic or bicarbonate, 30. The volume to be administered is that judged clinically to correct the estimated deficit. Once rehydration is completed, hydration can be maintained during continuing diarrhea by alternating between the oral solution and water. Water can be provided by breast-feeding on demand or by

giving plain water equal to about 50% of the volume of the oral solution administered (i.e., 2 parts ORT solution to 1 part water or breast milk).

If the complete formula is not available, ORT solutions for treatment of diarrhea can be made with salt and a source of glucose found in the home. The source of glucose is usually crude or sometimes refined household sugar; other sources, such as properly prepared rice powder, appear to be better in facilitating the absorption of electrolytes and water. A number of recent studies have shown clear reductions in stool output and duration of diarrhea when rice powder (which contains glucose, amino acids, and oligopeptides)[32,39] or soy[44] is used as a substrate. It has been demonstrated that the addition of an amino acid, such as glycine, to the standard glucose-electrolyte oral rehydration solution decreases duration of diarrhea and fecal fluid losses.[34,38] Rice powder and other cereals (or soy) are theoretically advantageous, because they contain amino acids or carbohydrate (in the form of glucose chains), each of which promotes sodium transport. Additionally, because the glucose is in the form of starch, more can be given without increasing the osmolarity. The upper limit of starch content has not yet been defined. Because infants less than 6 months old have incomplete development of pancreatic amylase, it is not certain whether they can completely digest these starches. If an improved ORT solution containing multiple water-soluble, organic molecules becomes available, it could increase the absorption of sodium and water and decrease the diarrheal volume and duration of diarrhea.

The small proportion of patients who have severe dehydration and shock, or who are unable to drink, require immediate intravenous therapy. The intravenous fluid should be administered rapidly, to reverse shock within 1 hour and to correct the estimated volume deficit within 2-4 hours. It should contain enough potassium and base to correct hypokalemia and acidosis. Suitable intravenous rehydration solutions, such as Ringer's lactate, have been described elsewhere.[52] Maintenance with ORT solution is then begun. Persistent vomiting is often given as a reason for withholding ORT solutions, but vomiting usually stops in the first 4 hours if ORT solutions are used.

EFFECTS OF ORAL REHYDRATION THERAPY ON NUTRITIONAL STATUS

Initial clinical observations found that children receiving oral rehydration solutions often wanted to eat within hours of the correction of fluid and electrolyte depletion.[33] That finding suggested that ORT could have an additional benefit on nutritional status.

This potential benefit has now been examined in at least seven studies of children with diarrhea (reviewed in Hirschhorn[17]). In these studies, nutritional status was measured, and continued feeding was urged for children treated either with or without ORT solutions. Children receiving the oral rehydration solution showed significantly greater gains in weight than children not receiving the solution; the difference persisted over time, even though not all gained weight at normal rates. The mean monthly increment in weight in the oral rehydration solution groups was 70 g more than that in the non-oral rehydration solution groups.

These results suggest that ORT programs can result in nutritional benefit when oral rehydration solution is combined with feeding. Such programs would be expected to be most effective where the current practice is to withhold food during illness. Other factors, such as the adequacy of a child's usual diet and the parent's ability to purchase food, will also influence the impact of ORT.

NUTRITIONAL THERAPY

The subcommittee recommends continued feeding during the active and early convalescent phases of diarrhea. The benefits to be expected vary with the nutritional quality of the foods offered, which can be increased by temporary fortification. Even the usual diet, however, is better than no food at all.

The primary objective of feeding should always be to minimize the adverse effects of the illness on nutritional status. A secondary objective is to promote normal intestinal mucosal renewal and absorptive and digestive functions. The objectives of therapy are the same whether it is provided at home, in a community health clinic, or in a hospital. Although more complex

individualized dietary treatment might be available in a hospital, the therapeutic principles are similar in all settings.

Feeding will not diminish the necessity to maintain fluid balance. Water and electrolytes must be included in the assessment of nutrient needs. As noted, proper rehydration is the first therapeutic goal. Once normal hydration status is restored--usually within a few hours--dietary intake can resume.

Ideal therapy provides the nutrients to meet the increased demands of illness and catch-up growth, in addition to the usual requirement for maintenance, growth, and physical activity. Choice of foods, mode of preparation, and frequency of feeding depend on the child's age, feeding history, and physiologic status. Particular attention should be given to the nutrient density of the food used, the quality of its carbohydrate and fat, the biologic value of its protein, and, if appropriate, its osmolarity. The need for specific nutrient supplements also must be considered.

Cultural factors are particularly important determinants of the management of diarrhea. Withholding of food by a child's caretaker and failure to compensate for a decrease in food intake during illness by increasing feeding during convalescence are major contributors to the adverse nutritional effects of diarrhea. In addition to folk beliefs, medical advice often supports the withholding of particular foods during and after diarrhea. It will be difficult to change folk beliefs without first obtaining the support of the various medical practitioners in the community. Careful attention will need to be paid to this group.

The development of specific protocols for the dietary management of acute diarrhea in different settings goes beyond the scope of this discussion. In some cases, specific questions will need to be answered and protocols tested before a diet is recommended. However, sufficient information is available to provide guidance that can be useful in the development of clinical protocols for all levels of care--home, community-based clinic, and hospital.

CHOICE OF FOODS

Clear, pragmatic, and generally applicable sets of feeding recommendations need to be formulated for distinct sociocultural settings. In preparing such recommendations, it is important to understand the factors that affect food choices and target populations. Criteria for choosing diets to meet normal requirements and the additional needs for catch-up growth should include the nutrient composition and density of the foods, familiarity of the foods, and the possibility of complementary nutrient mixtures that maximize absorption, particularly that of carbohydrates. The development of specific feeding recommendations is constrained by cultural norms and practices, economic limitations, the availability of foods, and difficulty in preparing foods in the home. Although the immediate availability of specific foods and their costs usually are considered early in treatment, their continued availability and costs during the longer period of convalescence and catch-up growth are equally important.

Food choices should be influenced by preillness feeding histories. For example, breast-feeding should be continued if possible. If a breast-fed child less than 6 months old is growing normally, it can be assumed that lactation is adequate and that nutritional deficits can be corrected with breast milk alone. Ideally, normal growth can be documented from measurements taken during routine examinations. If those data are not available, weight for length greater than the fifth percentile can be used as a crude indicator that breast milk is adequate. For infants older than 6 months with or without wasting, breast-feeding should be continued, but should be complemented with other foods. For the child who has been weaned from human milk, appropriate, available weaning foods must be defined in each locale.

The quality of the mixture of dietary proteins should be considered in selecting foods either to complement breast milk or to provide all a child's nutrient intake. Protein quality should be assessed on the basis of digestibility and the balance of essential amino acids, which are determinants of the efficiency with which the protein is used for maintenance and growth. Estimates of protein quality are found in

several reference documents, such as Energy and Protein Requirements.[14,15] Animal protein generally is more digestible and of higher biologic quality than plant protein. However, processing techniques can be used to improve digestibility of vegetable protein, and proteins from different sources can be mixed to improve their combined food value. For example, the value of wheat-flour protein is inferior to that of casein, but their combination in approximately equal proportions (55% wheat, 45% casein) has a value equivalent to that of 100% casein; the protein value of a corn and black bean mixture (equal proportions) is substantially higher than that of either component; and the value of a mixture of corn and milk proteins (equal proportions) is higher than that of either component. Clinical and dietetic personnel must be encouraged to identify locally available foods that can be combined to increase food value economically.

Allergenic proteins, such as those found in cow's milk, can easily cross a damaged intestinal mucosa and sensitize a child. However, the subcommittee believes that this risk is small, compared with the benefits of continued nutrient intake. Known sensitivity to specific foods contraindicates their use in dietary management in an individual case.

On the basis of the fat-to-energy ratio of human milk,[2] which is considered to provide an optimal combination of nutrients for an infant, the subcommittee suggests that fat should supply about 40-50% of dietary energy during the first 6 months of life and approximately 35-40% for the remainder of early childhood. As the fat content falls further and further below the recommended proportions, the quantity of food needed to supply appropriate amounts of energy becomes excessively large; that progression increases the risk that energy intake will be inadequate. Vegetable fats that include relatively high proportions of unsaturated fat or fats of medium chain length are recommended for the first 6 months of life and are preferred during the early phases of treatment for diarrhea, because they are generally more digestible and absorbable than highly saturated, long-chain fats.[13] Plant-seed oils (e.g., corn and soy) are relatively high in unsaturated fats, including the essential fatty acids. In contrast, coconut oil is more saturated and contains relatively

high proportions of medium-chain-length fats, but contains practically none of the essential fatty acids.[1] Although sufficient information is not available to make specific recommendations, a combination of unsaturated fats and mixed long-chain saturated fats should lead to better absorption than saturated fats alone. Although malabsorption of fats does not appear to exacerbate diarrhea, it does prolong nutritional rehabilitation and adversely affects the retention of nitrogen when protein intake is marginal.

Carbohydrates usually account for 35-55% of dietary energy during early infancy.[3] The principal types of dietary carbohydrate are starches and the disaccharides sucrose and lactose. Although the feeding of lactose to infants with gastroenteritis might be considered unwise, because of the recognized loss of intestinal lactase activity during intestinal infection, this type of acquired lactase deficiency is seldom total. Lactose at a concentration equivalent to that of half-strength cow's milk is generally well tolerated in diarrhea, especially in mixed foods, such as milk and cereal combinations. Sucrose, the other major dietary disaccharide, and processed vegetable starches usually are easily digested and absorbed by children with diarrhea. The potentially adverse effects of dietary carbohydrate can be minimized by multiple feedings of small amounts of mixtures of carbohydrates. This strategy is the least likely to strain possibly decreased capacity for carbohydrate digestion.

The potential for carbohydrate intolerance should be carefully addressed in clinical protocols prepared for primary health care workers. Misconceptions about transient intolerance to carbohydrate all too often lead to prolonged withholding of food. As a practical matter, if single challenges with lactose-containing foods do not aggravate clinical symptoms, continued tolerance during convalescence may be assumed.

The selection of foods also requires the evaluation of bulk and nutrient concentrations relative to energy content. One must consider gastric capacity, number of feedings per day, and nutrient needs of the child. If the amount of food that meets estimated energy needs exceeds the expected gastric capacity, the diet is too bulky. Some examples of energy-bulk relationships are

shown in Table 1. Bulk can be reduced by increasing the fat content of the diet. Infections accompanied by vomiting or the consumption of foods with high osmolarity or fat content will slow gastric emptying and often decrease tolerance to bulk. To minimize these problems, frequent feedings (e.g., every 2-4 hours, depending on the age of the child) of smaller quantities are highly desirable. Estimates of the energy density necessary to meet energy requirements are shown in Table 2.

Ideally, foods should provide twice the protein-to-calorie ratio that is normally required. No food is likely to satisfy this ratio for all essential nutrients at all ages, so supplementation or fortification with key nutrients might be needed for nutrient replenishment. Mixing of plant and animal foods often increases the nutrient-to-calorie ratio substantially. Diet manuals, such as Cameron and Hofvander's Manual for Feeding Infants and Young Children,[9] and nutrition texts, such as Latham's Human Nutrition in Tropical Africa,[23] suggest specific, practical approaches for reducing food bulk and increasing nutrient density. Cameron and Hofvander[9] include sample recipes that could be developed and tested for local use.

When a child's clinical status does not permit the introduction of complex foods at the beginning of treatment, the addition of starches, cereal powders, proteins, amino acids, or small polypeptides to standard oral rehydration solutions can be beneficial. Such additions might speed rehydration by reducing stool volume and at the same time mitigate energy and protein deficits. If this feeding regimen is adopted, the child should be offered more complex foods within 12 hours.

FOOD PREPARATION

In addition to the nutritional concerns described above, preparation of food should consider consistency, digestibility, and acceptability. Dilute watery paps or soups and excessively bulky foods should be avoided as primary nutrient sources if possible. When formulated appropriately, watery paps or soups can be used as

TABLE 1

Volumes of Cooked Rice and Boiled Potatoes Required to Meet Energy Needs of Normal Infants[a]

Age mo	Energy Requirements kcal[b]	Gastric Capacity, ml (A)	Required Volume of Rice,[c] ml (B)	Volume-to-Capacity Ratio (B/A)	Required Volume of Potatoes,[d] ml (C)	Volume-to-Capacity Ratio (C/A)
6	900	250	1,145	4.6	1,800	7.2
12	1,000	300	1,275	4.3	2,000	6.7
18	1,250	325	1,590	4.9	2,500	7.7

[a]Calculated by subcommittee.
[b]Data from FAO/WHO,[14] rounded to nearest 50 kcal.
[c]Assumes 1.1 kcal/g and 1.4 ml/g of cooked rice. Calculated from data on weight and kilocalories from Adams,[1] using 240 ml/cup. All values rounded.
[d]Assumes 0.75 kcal/g and 1.5 ml/g, calculated from data on weight and kilocalories from Adams,[1] using 240 ml/cup. All values rounded.

TABLE 2

Minimal Dietary Energy Density Needed to Satisfy Energy Requirements According to Age and Number of Feedings Per Day[a]

	Number of Feedings Per Day	Age, mo 3-5	6-8	9-11	12-23	24-36
Expected body weight, kg[b]		6.7	8.3	9.6	11.4	13.6
Usual energy requirement, kcal/day[c]		770	915	1,010	1,175	1,360
Estimated gastric capacity, ml[d]		200	250	290	340	410
Energy density necessary to meet energy requirement, kcal/100 ml[e]	8	48	46	44	43	41
	6	64	61	58	58	55
	4	96	92	87	86	83

[a]Calculated by subcommittee.
[b]50th percentile of National Center for Health Statistics reference weights.[16]
[c]Product of expected body weight and FAO/WHO[14] energy requirements of 115, 110, 105, 103, and 100 kcal/kg-day for ascending age categories.
[d]Estimated as 3% of body weight, rounded to nearest 10 ml.[29]
[e][100 (energy requirement)/(feedings/day)]/(gastric capacity).

adjuncts to fluid and electrolyte therapy, but never as a complete diet, because the concentrations of energy and nutrients in these preparations are usually too low.

Digestibility can be influenced in various ways. Local food-processing techniques should be used whenever possible, because of their familiarity to the population. For example, the digestibility of legumes can be improved through familiar cooking, fermenting, or germinating techniques that are not ordinarily used for infant feeding; particle size can be reduced by using simple food mills. If it is desirable to reduce lactose content, partially fermented products, such as yogurt, can be used. Mixing dried-milk preparations with vegetables or cereals also reduces the lactose content of the final diet potentially without reducing the biologic value of the milk protein substantially.

Because adequate food storage facilities are generally not available in the home, use of freshly prepared foods to minimize microbial contamination and growth should be encouraged. Reoffering of previously prepared food might be unavoidable, but reheating to a boil before feeding will reduce the hazards of consuming heavily contaminated food.

Effective ways of communicating desirable food preparation practices need to be developed. For example, food preparation in a clinic or hospital can serve as an excellent educational tool for mothers*, and the opportunity should be taken whenever possible. Home visits by health care workers to reinforce food selection and food preparation lessons may well be essential for program success.

FREQUENCY AND PROGRESSION OF FEEDING

Breast-fed infants should continue to be nursed, even during rehydration, by alternating between oral rehydration solutions and breast milk. Recent studies

*For convenience, "mother" is used to refer to the person with primary responsibility for the care of a child.

have shown that breast-feeding is an effective adjunct to ORT and offsets the need to provide plain water.[20,22]

Meals should be small and frequent in the early phase, because smaller meals are better tolerated. For older infants, at least six feedings a day should be attempted early in treatment; more frequent feedings are often necessary in younger infants.

When children are hospitalized and refuse to eat, it is reasonable to consider continuous nasogastric feeding. This approach takes full advantage of residual digestive and absorptive capacities through the slow, steady introduction of small quantities of food. Nasogastric feeding might increase stool frequency without markedly increasing stool volume. The first meal by this route should consist of a 50% dilution of a 0.7-kcal/ml formulation; it should be followed in 3-4 hours by a meal that is diluted by 25% and then by a full-strength meal at the next feeding. Various strategies should be considered. For example, high volumes of dilute feedings might be tolerated better than equivalent amounts of nutrients in more concentrated feedings in early phases of treatment. When continuous nasogastric feeding is chosen, special care must be taken to ensure that the protocols for preparation and delivery include steps to minimize contamination. As in the preparation of other foods, it is best to prepare these immediately before use and not to leave more food than needed for 4 hours of feeding at room temperature at the bedside.

During convalescence, defined as extending from cessation of liquid stools to return to preillness nutritional status, the quantity and frequency of feeding are determined by ad libitum intakes. Keeping track of a child's weight will ensure that ad libitum intakes meet the estimated nutrient needs and that the rate of recovery is appropriate. Flexibility in the feeding regimen promotes rapid convalescence. The early resumption of the customary feeding pattern, which probably includes three or four meals per day for older infants and very young children, is unlikely to provide sufficient nutrients for full recovery in a reasonable period.

MONITORING NUTRITIONAL THERAPY FOR DIARRHEA

In the monitoring of nutritional therapy for diarrhea, close clinical observation of the child--including food intake, willingness to eat, activity, and apparent discomfort--might be more useful than merely keeping track of the frequency, quantity, and quality of stools.

The mother plays a key role in the management of the dietary intake of a child with acute diarrhea, and her ability to assess the child's progress is therefore critical. To help gain the mother's confidence, health workers need to be sympathetic to her perception of the cause, course, and desired treatment for diarrhea. Many cultures distinguish a considerable array of diarrheal illnesses, which have different causes and treatments. These can be the basis for deriving credible, simple, and physiologically sound guidelines to help a family manage diarrhea in the home, as well as to decide when a child should no longer be treated at home, but should be taken to a clinic or hospital. Easily recognized indicators of the severity of illness should be used in the formulation of these guidelines--e.g., frequency of stools, duration of illness, clinical signs of dehydration, state of alertness, willingness to eat and drink, fever, and blood in the stools. Primary health care workers also need criteria for identifying infants who require more individualized attention. The criteria should reflect educational and physical resources available at each level of health care--home, clinic, and hospital. Sophisticated indicators of clinical status would be useful (e.g., measurement of fluid input and stool output), but daily monitoring of weight gain is more feasible and highly useful. In an optimal regimen, a daily gain of at least 20 or 30 g in a previously healthy child can be expected, with much more weight gain seen in a recovering child who had been undernourished.

Whenever care outside the home is warranted, health workers should involve the mother to the greatest extent possible. If she is taught basic facts about rehydration and feeding and participates in her child's care and recovery, she is more likely to recognize the importance of feeding during diarrhea and to continue feeding during future episodes. Ideally in all cases,

the mother should feed the child, for she usually has the experience necessary to succeed in this feeding. In many societies, however, women are overwhelmed with demands on their time, and finding the time necessary for the almost continuous feeding required for rapid recovery is difficult. If the time required for the optimal care of an acutely ill child is beyond the mother's resources, older siblings, grandparents, and fathers can often be enlisted to share the responsibility.

Although following these guidelines will usually result in a successful outcome, dietary management sometimes fails. Failure cannot be predicted, but it is most likely in children who were already moderately to severely malnourished. In such children, salt and water deficits can be corrected, but hypokalemia, common in undernourished children, might persist for several days. Potassium-containing foods (e.g., citrus juices and bananas) are useful adjuncts to oral rehydration. Whether at home or in the clinic, failure to respond can be anticipated if the patient's hydration status does not improve within 24 hours of the beginning of oral rehydration and dietary management.

Once feeding begins, refusal to eat, extensive vomiting after eating, and increased stool output are signs of food intolerance. Abdominal distention and complaints associated with the production of gas or explosive diarrhea are also important signs of food intolerance and are usually related to the carbohydrates being fed. High stool acidity and the presence of large amounts of reducing substances in the stool are due to malabsorption of carbohydrates. If clinical status is clearly worsening, the carbohydrates being fed should be changed or lessened. The presence of undigested food particles in the stool is evidence of the need for longer cooking time, greater use of refined raw materials, or the use of more finely pureed foods.

In adjusting dietary management because of these adverse clinical responses, it is important to stress that it is the child, and not the stool, that is being treated. Feeding should continue even in children whose diarrheal losses have continued, if their intake and weight gain are appropriate. Discontinuation of feeding should not be considered an option. If substantial

diarrhea continues, fluid replacement is necessary--with either oral rehydration solution or, when absolutely indicated, intravenous fluids--and the diet should not be changed too often. It usually takes 2-3 days to assess clinical response. This allows time for the natural diarrhea process to abate and any complications of feeding to become apparent. Continued feeding often improves absorptive capacity, as substrates needed for tissue repair are provided; however, treatment of more difficult cases might require the introduction of simpler, more easily digested foods.

ANTIBIOTIC AND ANTIDIARRHEAL AGENTS

Adequate fluid replacement alone can usually prevent death from secretory (watery) diarrhea. However, in some severe cases of secretory diarrhea (e.g., in cholera), adjunctive therapy with antibiotics markedly reduces the duration and volume of diarrhea. Antimicrobial therapy is more important for dysenteric diarrheal illness than for secretory diarrhea. Antibiotics might decrease the duration of diarrhea, the period of discomfort, the potentially lethal complications of gram-negative bacterial infection, and the nutritional deterioration caused by excessive loss of protein in stools in such infection.

Antidiarrheal drugs--such as diphenoxylate, loperamide, tincture of opium, and paregoric--can reduce symptoms of abdominal cramps, but do not substantially alter diarrheal stool losses and might even prolong the illness. Adsorbents--such as kaolin, pectin, and activated charcoal--have no value in the treatment of infectious diarrhea. Bismuth subsalicylate in very large doses decreases the number of stools, but is not a practical or cost-effective therapeutic agent. In addition, substantial absorption of the salicylate might lead to toxicity, especially in children. Antisecretory drugs might reduce stool volume moderately, but are not effective enough to justify the expense and the risk of side effects.

3

RESEARCH RECOMMENDATIONS

The subcommittee identified a number of gaps in knowledge that have limited its ability to make quantitative judgments. These gaps are outlined below as priorities for basic and programmatic research. Basic research addresses questions pertaining to disease mechanisms and etiology, and the information it yields tends to be generalizable to varied local situations. Programmatic, or operational, research tends to be more country-specific, and the research questions and priorities usually need to be determined for each country.

BASIC RESEARCH

The following subjects need to be addressed by basic research:

- Effects of agent-specific diarrhea on nutrient absorption and utilization in age-specific populations at various levels of nutritional status. (Information is particularly scant on micronutrient metabolism and depletion.)

- Methods for rapid assessment of specific nutrient depletion.

- Determinants of anorexia and its role in decreasing nutrient intakes during and after diarrhea.

- Effects of different diets and feeding protocols on dehydration, vomiting, severity and duration of diarrhea, and nutritional status during diarrhea.

- Effects of different diets and of antibiotic therapy on intestinal flora and digestive and absorptive capacities during diarrhea.

- Effects of different diets and feeding protocols on digestive and absorptive capacities and nutritional repletion during convalescence.

- Effects of different diets and feeding protocols on the local immune function of the gastrointestinal tract in age-specific populations.

- Effects of early feeding in diarrhea on the incidence and severity of later diarrheal episodes and on the impairment of intestinal function in later episodes.

PROGRAMMATIC RESEARCH

The following subjects need to be addressed by programmatic research:

- Cultural determinants of feeding practices during and after diarrhea.

- Most appropriate foods for dietary management of diarrhea, with particular reference to type, quantity, processing, preparation, and acceptability of local foods.

- Most effective methods of influencing behavior of health workers and mothers in dietary management of diarrhea.

- Efficacy of rehydration solutions made with household staple foods for replacing body fluid, shortening duration of diarrhea, preventing or reducing dehydration, and improving nutritional status.

4

SUMMARY

Acute diarrhea, besides causing the loss of water and essential electrolytes and leading to dehydration, has adverse effects on nutritional status. Water and electrolytes are replaced with ORT solutions; nutritional consequences require additional intervention. Reduction in food intake, decrease in absorption of nutrients, losses of body stores, and increases in nutrient requirements--all associated with diarrhea--contribute to malnutrition, and in some cases death. On the basis of its review of these nutritional consequences of diarrhea and its assessment of the potential complications of continued feeding during diarrhea, the subcommittee has determined that continued feeding is both safe and beneficial. General recommendations for the nutritional management of diarrhea, discussed in more detail in Chapter 2, are summarized in the following paragraphs. The subcommittee also recognizes that gaps in knowledge still limit understanding of the biologic effects of diarrhea and hinder development of specific protocols for its nutritional management. Research to fill the gaps identified by the subcommittee is outlined in Chapter 3.

- Children should continue to be fed during acute diarrhea because feeding is physiologically sound and will prevent or minimize the deterioration of nutritional status that normally accompanies such illness.

- A child with acute diarrhea should be fed the most nutrient-dense foods available in the household, i.e., foods with the highest proportion of nutrients and calories relative to bulk. Such foods must be offered frequently (at least once every 3 or 4 hours) and to the extent that the child is willing to eat.

- Because cessation of diarrhea is not equivalent to recovery and nutrient deficits persist, feeding extra food (above usual intake) must continue after diarrhea ceases. During recovery, an intake of at least 125% of normal should be attempted with nutrient-dense foods; it should continue at least until the child reaches preillness weight and ideally until the child achieves normal nutritional status, as measured by expected weight for height or weight for length. This might take several weeks or longer, depending on the degree of deficit.

- All providers of health care (physicians, nurses, mothers, and others) must be included in educational programs aimed at teaching appropriate dietary management and identifying children who need referral.

APPENDIX

ENERGY NEEDS FOR RECOVERY FROM THE EFFECTS OF DIARRHEA

Tables A-1 and A-2 present the subcommittee's estimates of the amounts of energy that must be consumed for various periods to permit nutritional recovery after diarrhea. The figures are based on several assumptions regarding weight loss during illness (0, 250, or 500 g), preillness nutritional status (95%, 90%, or 80% of expected weight for length), and period of recovery to preillness weight or to 95% of expected weight for length (5, 10, or 20 days).

Examination of the tables suggests the following general conclusions:

- The estimates for required energy intake for no weight loss during illness and for children initially at 95% of expected weight for length are reasonably close to the FAO/WHO[14] recommendations for age. The FAO/WHO values are 110, 105, and 100 kcal/day for ages of 6, 12, and 24 months, respectively.

- A smaller daily weight gain and hence a lower daily energy consumption are acceptable if the recovery period is longer.

- Younger children must gain more weight daily, and hence consume more energy, than older children for any given set of assumptions regarding severity of illness-induced weight loss, nutritional status, or duration of recovery.

- To reach normal weight, children who were already undernourished must gain more weight daily than adequately nourished children, if gain is expressed as a fraction of body weight; thus, they must consume more energy.

- Younger children, especially if undernourished before illness, with greater illness-induced weight loss usually require more than 2 weeks of convalescence to replace lost weight and substantially more time to achieve 95% of expected weight for length.

- Even older children require more than 2 weeks to recover nutritionally if they were already undernourished, particularly if the goal is to achieve 95% of expected weight for length.

To relate Table 2 to Tables A-1 and A-2, one would have to correct the densities in Table 2 for the desired energy intake per day. For example, a 6-month-old child whose preillness weight for length was 90% of expected and who lost 250 g during illness would require 166 kcal/kg-day or 1195 kcal/day to recover the lost weight in 5 days. Such a child would require a minimal energy intake of 80 kcal/100 ml—100(1195 kcal per day/6)/250 ml if receiving six feedings per day. Because the maximal energy density usually recommended for young children is 100 kcal/100 ml, it is obvious that more feedings per day would be required to achieve some of the higher growth rates shown in Tables A-1 and A-2.

TABLE A-1

Estimated Daily Weight Gain and Energy Intake Required to Replace Weight Lost During Illness According to Amount of Weight Lost and Duration of Recovery Period[a]

Age, mo	Assumed Preillness Weight,[b] kg	% Ref. Wt.	Weight Loss During Illness,[c] g	Expected Daily Weight Gain For Age,[d] g	Daily Weight Gain Required to Replace Illness-Induced Loss in Stated Number of Days[e]						Daily Energy Intake Required to Replace Illness-Induced Loss in Stated Number of Days[f] kcal/kg		
					5 Days		10 Days		20 Days		5 Days	10 Days	20 Days
					g	g/kg	g	g/kg	g	g/kg			
6	7.6	95	0	18	18	2.4	18	2.4	18	2.4	104	104	104
			250		68	8.9	43	5.7	30	3.9	161	133	117
			500		118	15.5	68	8.9	43	5.7	230	161	133
	7.2	90	250		68	9.4	43	6.0	30	4.2	166	135	120
			500		118	16.4	68	9.4	43	6.0	—	166	135
	6.4	80	250		68	10.6	43	6.7	30	4.7	176	142	126
			500		118	18.4	68	10.6	43	6.7	—	176	142
12	9.5	95	0	13	13	1.4	13	1.4	13	1.4	97	97	97
			250		63	6.8	40	4.2	28	2.9	143	120	108
			500		113	13.1	63	6.8	40	4.2	189	143	120
	9.0	90	250		63	7.1	40	4.4	28	3.1	146	121	110
			500		113	12.8	63	7.2	40	4.4	196	146	121
	8.0	80	250		63	7.2	40	5.0	28	3.5	146	121	110
			500		113	14.4	63	8.1	40	5.0	210	154	127
24	11.8	95	0	13	13	1.3	13	1.3	13	1.3	96	96	96
			250		63	5.5	40	3.4	28	2.4	131	112	104
			500		113	9.7	63	5.5	40	3.4	168	131	112
	11.2	90	250		63	5.8	40	3.6	28	2.5	134	114	105
			500		113	10.3	63	5.8	40	3.6	174	134	114
	10.0	80	250		63	6.5	40	4.0	28	2.8	140	118	107
			500		113	11.9	63	6.5	40	4.0	184	140	118

[a]Estimates derived by subcommittee. Recovery defined as return to preillness weight.

[b]95%, 90%, or 80% of expected weight for length, where expected weight for length is 50th percentile of National Center for Health Statistics (NCHS) reference weight for length for males.[16] Corresponding preillness length is 50th percentile of NCHS length for males of stated age.[16]

[c]Arbitrarily chosen as 0, 250, or 500 g. Losses not only include absolute losses, but also reflect weight that should have been gained during period of illness.

[d]Derived from NCHS tables.[16]

[e]Calculated in grams by dividing illness-induced weight loss by duration of recovery (5, 10, or 20 days) and adding usual expected daily weight gain for age. Calculated in terms of body weight on basis of preillness body weight--a slight oversimplification, in that mean weight during recovery should be used. These minor differences would not affect interpretation.

[f]Daily energy intake estimated by using regression of weight gain (g/kg of body weight per day) on energy intake (kcal/kg-day) for children with marasmus ($y = 0.113x - 9.31$), according to Ashworth et al.[4] Values for required energy consumption were reported only if desired amount of weight could be gained within stated period through energy intake of no more than 225 kcal/kg-day, which itself would be difficult to achieve in most field settings.

TABLE A-2

Estimated Daily Weight Gain and Energy Intake Required to Reach 95% Weight for Length According to Illness Weight for Length, Amount of Weight Lost, and Duration of Recovery Period[a]

Age, mo	Assumed Prelllness Weight,[b] kg	% Ref. Wt.	Weight Loss During Illness,[c] g	Expected Daily Weight Gain For Age,[d] g	Daily Weight Gain Required to Reach 95% Weight for Length in Stated Number of Days[e]						Daily Energy Intake Required to Reach 95% Weight for Length in Stated Number of Days[f] kcal/kg		
					5 Days		10 Days		20 Days		5 Days	10 Days	20 Days
					g	g/kg	g	g/kg	g	g/kg			
6	7.6	95	0	18	18	2.4	18	2.4	18	2.4	104	104	104
			250		68	8.9	43	5.7	30	3.9	161	133	117
			500		118	15.5	68	8.9	43	5.7	220	161	133
	7.2	90	250		148	20.6	83	11.5	50	6.9	—	184	143
			500		198	27.5	108	15.0	63	8.8	—	215	160
	6.4	80	250		308	48.1	163	25.5	90	14.1	—	—	207
			500		358	55.9	188	29.4	103	16.1	—	—	225
12	9.5	95	0	15	15	1.6	15	1.6	15	1.6	97	97	97
			250		65	6.8	40	4.2	28	2.9	143	120	108
			500		115	12.1	65	6.8	40	4.2	189	143	120
	9.0	90	250		165	18.3	90	10.0	53	5.9	—	171	135
			500		215	23.9	115	12.8	65	7.2	—	196	146
	8.0	80	250		365	45.6	190	23.8	103	12.9	—	—	197
			500		415	51.9	215	27.0	115	14.4	—	—	210
24	11.8	95	0	15	15	1.3	15	1.3	15	1.3	96	96	96
			250		65	5.5	40	3.4	28	2.4	131	112	104
			500		115	9.7	65	5.5	40	3.4	168	131	112
	11.2	90	250		185	16.5	100	8.9	58	5.2	—	141	128
			500		235	21.0	125	11.2	70	6.3	—	182	138
	10.0	80	250		415	42.5	220	22.0	118	11.8	—	—	187
			500		479	47.5	245	24.5	130	13.0	—	—	197

[a]Estimates derived by subcommittee. Recovery defined as return to 95% of expected weight for length.

[b]95%, 90%, or 80% of expected weight for length, where expected weight for length is 50th percentile of National Center for Health Statistics (NCHS) reference weight for length for males.[16] Corresponding prelllness length is 50th percentile of NCHS length for males of stated age.[16]

[c]Arbitrarily chosen as 0, 250, or 500 g. Losses not only include absolute losses, but also reflect weight that should have been gained during period of illness.

[d]Derived from NCHS tables.[16]

[e]Calculated in grams by dividing difference between 95% of expected weight for length and prelllness weight by number of days of recovery and adding daily weight gain from Table A-1. Recovery was defined as recovery of lost weight plus gain required to achieve 95% of expected weight for length. 95th percentile reference weights are 7.6, 9.5, and 11.8 kg for ages of 6, 12, and 24 months, respectively. Calculated in terms of body weight on basis of prelllness body weight—a slight oversimplification, in that mean weight during recovery should be used. These minor differences would not affect interpretation.

[f]Daily energy intake estimated by using regression of weight gain (g/kg of body weight per day) on energy intake (kcal/kg-day) for children with marasmus ($y = 0.113x - 9.31$), according to Ashworth et al.[4] Values for required energy consumption were reported only if desired amount of weight could be gained within stated period through energy intake of no more than 225 kcal/kg-day, which itself would be difficult to achieve in most field settings.

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